ACUTE TOXICOLOGY SUMMARY

SULFURIC ACID AND OLEUM

Molecular formula	Molecular weight	Synonyms	CAS Registry Number
H_2SO_4	98.1	sulfuric acid; dithionic acid; pyrosulphuric acid	7664-93-9
SO_3	80.07	sulfur trioxide	7446-71-9
$H_2SO_4 + SO_3$		Oleum	8014-95-7

I. Acute Toxicity Exposure Levels (for a 1-hour exposure)

Inhalation reference exposure level **120 μg/m³**
Critical effect(s) small changes in airway function tests, especially in asthmatics
Hazard Index target(s) Respiratory System

II. Physical and Chemical Properties (HSDB, 1994)

Description	colorless liquid
Molecular formula	H_2SO_4 (sulfuric acid) $H_2SO_4 + SO_3$ (oleum)
Molecular weight	98.1 (sulfuric acid)
Density	1.84 g/cm^3 (sulfuric acid) 1.91-1.97 g/cm^3 @ 15°C (oleum)
Boiling point	315-388°C
Melting point	10.4°C
Vapor pressure	0.001 mm Hg @ 20°C
Solubility	soluble in water
Odor threshold	1 mg/m³
Metabolites	SO_4^{2-}, neutral sulfur
Conversion factor	1 ppm = 4.08 mg/m³

Description of oleum

Oleum is supersaturated anhydrous H_2SO_4 with varying concentrations of free sulfur trioxide (SO_3). Upon contact with atmospheric moisture, SO_3 is rapidly converted to H_2SO_4 mist. Exposure to sulfur trioxide is, therefore, equivalent to exposure to H_2SO_4.

III. Major Uses or Sources

Sulfuric acid is a strong acid used as an intermediate for linear alkylbenzene sulfonation surfactants used in dyes; in petroleum refining; for the nitration of explosives; in the manufacture of nitrocellulose; in caprolactam manufacturing; and as a drying agent for chlorine and nitric acid.

IV. Acute Toxicity to Humans

The irritant properties of H_2SO_4 account for its acute as well as its chronic effects. Two properties of concentrated H_2SO_4, its acidity and its hygroscopic potential, make it particularly corrosive as compared to diluted H_2SO_4 to the skin, eyes and respiratory tract. In splash accidents involving H_2SO_4, the heat, liberated by dilution of the concentrated acid with water, can add thermal burn to the chemical injury caused by the acid itself. Sulfuric acid exposure results in irritation of the tracheobronchial tree, which leads to bronchoconstriction and altered lung function. Sim and Pattle (1957) reported that in healthy volunteers a range of exposures, from 2.9 to 39 mg/m^3, resulted in coughing, bronchoconstriction, and rales. In this study, H_2SO_4 mists of 20.8 mg/m^3 were nearly intolerable to the volunteers exposed for 30 minutes. Wet mists were also more potent inducers of irritation than dry mists at the same exposure levels.

Delayed effects of sulfuric acid exposure may be seen in some individuals. Utell *et al*. (1983) reported that in normal volunteers a single exposure to 0.45 mg/m^3 for 4 hours resulted in increased bronchoconstriction 24 hours later. Concomitant exposures to other pollutants in industrial areas, including SO_2, ozone, and metallic aerosols, can add to, or potentiate the irritancy of H_2SO_4 (Amdur, 1989). This is of particular concern for asthmatic individuals, who may be more sensitive than non-asthmatics to the irritant effects of H_2SO_4. In human asthmatic subjects, exposure to 450 µg/m^3 sulfuric acid for 16 minutes decreased airway conductance but the magnitude of the decrease was not clinically significant (Utell *et al*., 1984).

Dental erosion has been reported in battery plant workers exposed chronically to sulfuric acid mist at 0.8 mg/m^3 for several months (Malcolm and Paul, 1961). Dose-dependent dental erosion has also been described in workers exposed to an average concentration of 0.23 mg/m^3 for at least 4 months (Gamble *et al*., 1984).

A report of acute respiratory distress syndrome (ARDS) in a 23 year-old worker exposed to unknown high concentrations of sulfuric acid for over 30 minutes showed parenchymal opacities on roentgenogram and deficits in lung function that resolved within 6 weeks of treatment (Knapp *et al*., 1991).

Predisposing Conditions for Sulfuric Acid Toxicity

Medical: The young may be more sensitive than adults to the lethal effects based on guinea pig LC_{50} values (Amdur, 1952a). Asthmatics are more sensitive to the pulmonary irritation produced by exposure to sulfuric acid.

Chemical: Factors increasing the irritancy of sulfuric acid include: 1) adding steam to sulfuric acid mist; 2) high humidity in general; 3) large particle size (> 10 microns) (Sim and Pattle, 1957); and 4) concomitant exposure to other pollutants from automobile exhaust (SO_2, ozone, and metallic aerosols) (Amdur, 1989).

V. Acute Toxicity in Laboratory Animals

The LC_{50} in young guinea pigs is 18 mg/m³ and in old guinea pigs is 50 mg/m³ for an 8-hour exposure (Amdur 1952a). The LC_{50} in rats is 1,402 mg/m³ for a one-hour exposure (RTECS, 1994).

Schlesinger *et al*. (1990) showed that daily one hour exposures for five days to 250 µg/m³ H_2SO_4 caused a decrease in prostaglandins E_2, F_{2a}, and thromboxane B_2 in lavage fluid from rabbit lungs. Donkeys exposed to 102-106 µg/m³ H_2SO_4 for 1 hr/day, 5 days/wk, over 6 months developed significant impairment of normal bronchial clearance, with sustained effects for up to 3 months after cessation of treatment (Schlesinger *et al*., 1978). Exposure of monkeys to 2.43 -4.79 mg/m³ sulfuric acid for 78 weeks resulted in adverse histological changes in lung parenchymal tissue. In addition, decreased blood oxygenation was observed (Alarie *et al*., 1973).

Five squirrel monkeys exposed to 2.6 mg/m³ sulfuric acid for 1 hour exhibited significant (11%) increases in total respiratory system resistance compared with 5 sham-exposed monkeys, although no overt clinical signs of coughing, wheezing, or blinking were observed (Kleinman and Hackney, 1978).

VI. Reproductive or Developmental Toxicity

There are no confirmed studies that conclusively show reproductive or developmental toxicity linked to sulfuric acid exposure.

VII. Derivation of Acute Reference Exposure Level and Other Severity Levels (for a 1-hour exposure)

Reference Exposure Level (protective against mild adverse effects): **120 µg/m³ (30 ppb)**

Study	Utell *et al*., 1984
Study population	17 human asthmatics
Exposure method	inhalation
Critical effects	small changes in airway function, especially in asthmatics
LOAEL	1,000 µg/m³
NOAEL	450 µg/m³ (112 ppb)
Exposure duration	16 minutes
Extrapolated 1 hour concentration	120 µg/m³ (C^1 * 1 hr = 450^1 µg/m³ * 16/60 hr)
LOAEL uncertainty factor	1
Interspecies uncertainty factor	1

Intraspecies uncertainty factor	1
Cumulative uncertainty factor	1
Reference Exposure Level	120 µg/m³ (30 ppb)

The lowest observed effect level (considered a NOAEL) for a 16-minute exposure resulting in decreased airway conductance in human asthmatic subjects was 450 µg/m³ (112 ppb) sulfuric acid. The REL of 120 µg/m³ for a 1-hour exposure was derived using the formula $C^n * T = K$, where n = 1. The 24-hour California ambient air standard for sulfates is 25 µg/m³, and the 24-hour California ambient standard for particulate matter with a diameter at or below 10 microns (PM_{10}) is 50 µg/m³.

Level Protective Against Severe Adverse Effects

The National Research Council (NRC, 1986) derived a 60-minute EEGL (Emergency Exposure Guidance Level) of 1 mg/m³ for sulfuric acid. Exposure of humans to 5 mg/m³ H_2SO_4 for 15 minutes was tolerable to the subjects. Monkeys, exposed to 4.8 mg/m³ continuously over a 78 week period, showed some respiratory changes. Similar changes were seen in this study at a concentration of 2.4 mg/m³, but were not included by NAS in the EEGL document. Adjusting these results for time of exposure yielded an acceptable human exposure of 1 mg/m³ for 60 minutes. The AIHA (1989) ERPG-2 level of 10 mg/m³ does not consider LC_{50} data in guinea pigs of 18 mg/m³ (Amdur *et al*, 1952a). Furthermore, the ERPG document relies heavily on older studies that are either unpublished or poorly presented (Sim and Pattle, 1957). Thus, although the EEGL 60-minute value of 1 mg/m³ did not include respiratory changes in monkeys exposed to 2.4 mg/m³, this value is health protective based on a thorough review of the literature.

Level Protective Against Life-threatening Effects

No recommendation is made due to the limitations of the database.

Exposure of healthy, human subjects for 30 minutes to 20.8 mg/m³ H_2SO_4 was almost intolerable, causing coughing, bronchoconstriction and rales. LC_{50} values in young guinea pigs are reported to be 18 mg/m³, and 50 mg/m³ for older guinea pigs (Amdur *et al*., 1952a). Based on these results, the AIHA has set an ERPG-3 value for a 1 hour exposure of 30 mg/m³ as protective against the lethal effects of H_2SO_4. The ERPG-3 value may be inappropriately high based on the guinea pig 8-hour LC_{50} values (Amdur *et al*., 1952a). Silbaugh *et al*. (1981) also reported 22% mortality of guinea pigs exposed to 24.3 mg/m³ H_2SO_4 for 35 minutes. Consequently, this level cannot be recommended as the level protective against life-threatening effects.

NIOSH (1995) lists a revised IDLH for sulfuric acid of 15 mg/m³ based on acute inhalation toxicity data in humans (Amdur *et al*. 1952b) and animals (Amdur *et al*. 1952a; Treon *et al*. 1950). NIOSH states: "This may be a conservative value due to the lack of relevant acute toxicity data for workers exposed to concentrations above 5 mg/m³." This value would also not take into account sensitive human subpopulations.

VIII. References

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